Q: The zenith angle is the angle made by the sun's rays with the ____ to a ____ surface.

A: The zenith angle is the angle made by the sun's rays with the vertical (also known as the zenith) to a horizontal surface.

The zenith angle is important in solar energy calculations, as it determines the intensity of the sunlight received at a particular location & time. When the zenith angle is zero, the sun is directly overhead & the intensity of the sunlight is at its maximum. As the zenith angle increases, the intensity of the sunlight decreases. The zenith angle is typically measured in degrees & can range from 0 to 90 degrees.

Q: The efficiency of various types of collectors ____ with ____ temperature.

1. increases, decreasing
2. decreases, increasing
3. remains same, increasing
4. depends upon type of collector

A: The efficiency of various types of collectors typically decreases with increasing temperature.

The temperature of a solar collector can increase due to the absorption of solar radiation, which can lead to a decrease in the efficiency of the collector. This is because the temperature of the collector can affect the thermodynamic properties of the working fluid, such as its density & viscosity, which can affect the heat transfer process within the collector.

The efficiency of a solar collector is typically highest when the temperature of the collector is relatively low & decreases as the temperature increases.

Therefore:

- Option (ii) "decreases, increasing" is therefore the correct answer.
- Option (i) "increases, decreasing" is incorrect, as the efficiency typically decreases as the temperature increases.
- Option (iii) "remains same, increasing" is also incorrect, as the efficiency of a solar collector does not remain constant as the temperature increases.
- Option (iv) "depends upon type of collector" is also incorrect, as the relationship between efficiency & temperature is generally true for all types of collectors.

Q: A liquid flat plate collector is usually held tilted in a fixed position, facing ____ if located in the northern hemisphere.

A: A liquid flat plate collector is usually held tilted in a fixed position, facing south if located in the northern hemisphere.

The orientation of the collector is important in maximizing the amount of solar energy it can absorb & convert into useful heat.

In the northern hemisphere, the sun's rays are most directly overhead at noon when the sun is in the southern sky. By facing the collector towards the south, the collector can capture the maximum amount of sunlight throughout the day & throughout the year. In the southern hemisphere, the collector would be oriented towards the north to capture the maximum amount of sunlight.

The angle at which the collector is tilted can also affect its performance. A collector that is tilted at an angle that is equal to the latitude of the location will typically have the highest efficiency.

Q: The angle made in the horizontal plane between the horizontal line due south & the projection of the normal to the surface on the horizontal plane is ____

A: The angle made in the horizontal plane between the horizontal line due south & the projection of the normal to the surface on the horizontal plane is known as the surface azimuth angle.

The surface azimuth angle is a measure of the direction of the surface relative to due south (i.e. true south). It is typically measured in degrees ranging from -180 to 180 degrees, with 0 degrees corresponding to a surface that is oriented due south, -90 degrees corresponding to a surface oriented due west, -180 degrees corresponding to a surface oriented due north in clockwise direction, & 90 degrees corresponding to a surface oriented due east, 180 degrees corresponding to a surface oriented due north in anti-clockwise direction.

A surface with a positive azimuth angle will be facing east of south, while a surface with a negative azimuth angle will be facing west of south.

The surface azimuth angle is important in solar energy calculations, as it determines the amount of sunlight that a surface will receive at a particular location & time. It can be used in conjunction with the zenith angle, which is the angle made by the sun's rays with the vertical (zenith) to a horizontal surface, to determine the intensity & direction of the sunlight received by a surface.

Q: Of the following choices, which best describes or defines Biomass?

1. Massive living things
2. Inorganic matter that can be converted to fuel
3. Organic matter that can be converted to fuel
4. Petroleum

A: Biomass refers to organic matter that can be used as a source of energy, such as wood, agricultural residues, & plant matter. Biomass can be converted into various forms of fuel, such as bioethanol, biodiesel, & biogas, through processes such as fermentation & pyrolysis. Biomass is considered a renewable energy source because it can be replenished relatively quickly through the growth of new plants & the recycling of organic waste.

Therefore:

- Option (iii) "Organic matter that can be converted to fuel" best describes or defines biomass.
- Option (i) "Massive living things" is incorrect, as biomass does not necessarily refer to large living things.
- Option (ii) "Inorganic matter that can be converted to fuel" is also incorrect, as biomass is organic matter & not inorganic matter.
- Option (iv) "Petroleum" is also incorrect, as petroleum is a fossil fuel & not a form of biomass.

Q: Of the following choices, which best describes or defines geothermal energy?

1. Heat energy from volcanic eruptions.
2. Heat energy from hot springs.
3. Heat energy from inside the earth.
4. Heat energy from rocks on Earth's surface.

A: Geothermal energy is a form of renewable energy that is derived from the heat that is generated within the earth. This heat is generated by the decay of radioactive elements & the residual heat from the formation of the earth, & it is found in various forms, including geysers, hot springs, & geothermal reservoirs.

Geothermal energy can be harnessed through the use of geothermal power plants, which use the heat from the earth to generate electricity, or through the use of geothermal heat pumps, which use the heat from the earth to heat & cool buildings.

Therefore:

- Option (iii) "Heat energy from inside the earth" best describes or defines geothermal energy.

- Option (i) "Heat energy from volcanic eruptions" is incorrect, as geothermal energy is not necessarily related to volcanic eruptions.
- Option (ii) "Heat energy from hot springs" is also incorrect, as geothermal energy includes heat from other sources within the earth, not just hot springs.
- Option (iv) "Heat energy from rocks on Earth's surface" is also incorrect, as geothermal energy is derived from the heat within the earth & not from the surface of the earth.

Q: Which among the following is not an adverse environmental impact of tidal power generation?

1. Interference with spawning & migration of fish
2. Pollution & health hazard in the estuary due to blockage of flow of polluted water into the sea
3. Navigational hazard
4. None of the above

A: Option (iv) "None of the above" is not an adverse environmental impact of tidal power generation. All of the options listed are potential adverse environmental impacts of tidal power generation.

Option (i) "Interference with spawning & migration of fish" is an adverse environmental impact of tidal power generation, as the construction of tidal power facilities, such as dams & barrages, can alter the natural flow of water & interfere with the spawning & migration patterns of fish.

Option (ii) "Pollution & health hazard in the estuary due to blockage of flow of polluted water into the sea" is also an adverse environmental impact of tidal power generation, as the construction of tidal power facilities can block the flow of polluted water into the sea, leading to an accumulation of pollutants in the estuary & potentially posing a health hazard.

Option (iii) "Navigational hazard" is also an adverse environmental impact of tidal power generation, as the construction of tidal power facilities can create obstacles for ships & boats navigating in the area.

Q: What is fossil fuel?

A: A fossil fuel is a type of fuel that is formed from the remains of living organisms that have been buried & subjected to high pressures & temperatures over millions of years. Examples of fossil fuels include coal, oil, & natural gas.

Q: The fossil fuels like coal, oil & natural gas are at present supplying _____ % of the commercial energy

1. 25
2. 35
3. 75
4. 95

A: According to data from the International Energy Agency (IEA), fossil fuels (including coal, oil, & natural gas) accounted for about 75% of the world's primary energy consumption in 2019. However, this percentage is expected to decline over time as the use of renewable energy sources increases & the demand for fossil fuels decreases.

Given this information, option (iii) "75" is the closest to the correct answer, although it is worth noting that the exact percentage may vary depending on the specific context. Options (i) "25" and (ii) "35" are significantly lower than the actual percentage, while option (iv) "95" is significantly higher.

Q: Mention 4 advantages of renewable energy sources.

A: The 4 advantages of renewable energy sources are:

- They are environmentally friendly.
- They are replenished quickly.
- They are inexhaustible.
- They are abundant & widely available.

Q: What do you mean by DNI? What is the value of Solar constant?

A: DNI stands for "Direct Normal Irradiance". It is a measure of the intensity of solar radiation that is received at the surface of the earth without being absorbed or scattered when the sun is directly overhead. DNI is typically measured in units of watts per square meter (Wm^{-2}).

The value of the solar constant is approximately 1367 Wm^{-2}, although it can vary slightly due to factors such as the sun's distance from the earth & the earth's orbit around the sun.

Q: What is solar time? How is it different from LAT?

A: Solar time is a measure of time that is based on the position of the sun in the sky irrespective of the location from where it is observed. Solar time is typically measured

using a sundial, which measures the length of the shadow cast by the sun as it moves across the sky.

Solar time is different from Local Apparent Time (LAT), which is also a measure of time that is based on the position of the sun in the sky, but with respect to the location from where it is observed.

Q: Why orientation is needed in "concentrating type collectors"?

A: Orientation is important in "concentrating type collectors" because it determines the direction in which the collector is facing & the angle at which the solar radiation is received.

For example, a collector that is oriented towards the sun will receive more solar radiation than a collector that is oriented away from the sun. Similarly, a collector that is tilted at a steeper angle will receive more solar radiation than a collector that is tilted at a shallower angle.

In addition, the orientation of the collector can also affect the temperature of the collector. So, by carefully selecting the orientation of the collector, it is possible to minimize the temperature gradient across the collector & improve its efficiency.

Q: Mention the principle of solar furnaces.

A: A solar furnace is a device that uses solar energy to produce high temperatures for various industrial & scientific applications.

The principle of solar furnaces is based on the fact that the intensity of solar radiation increases as the surface area over which it is received decreases. By concentrating the solar radiation onto a small area, it is possible to produce extremely high temperatures of up to 3000°C, which would not be possible to produce using solar radiation alone.

Q: Mention different types of concentrating type solar collectors.

A: The different types of concentrating type solar collectors are:

- Parabolic trough collectors.
- Parabolic dish collectors.
- Linear Fresnel collectors.
- Solar towers.
- Solar concentrators.

Q: Mention four factors affecting biogas generation.

A: The four factors affecting biogas generation are:

- Feedstock.
- Temperature.
- pH.
- Oxygen.

Q: Mention the effects of aerodynamics of blades on wind power generation.

A: The aerodynamics of the blades of a wind turbine can have a significant impact on the efficiency and performance of the wind turbine. Some of the effects of aerodynamics on wind power generation include:

- Blade shape: Blades that are designed with a more aerodynamic shape can generate more lift and less drag, which can improve the efficiency of the wind turbine.

- Blade angle: Blades that are angled more towards the wind can generate more lift and less drag, which can improve the efficiency of the wind turbine.

- Blade twist: It's the way in which the angle of the blade changes along its length, which can also affect the efficiency of the wind turbine.

  Blades with a twist that is optimized for the wind speeds at different heights above the ground can generate more lift and less drag, which can improve the efficiency of the wind turbine.

- Blade pitch: It's the angle at which the blades are oriented relative to the rotor, which can also affect the efficiency of the wind turbine.

  Blades with a pitch that is optimized for the wind speeds at different heights above the ground can generate more lift and less drag, which can improve the efficiency of the wind turbine.

Q: What do you mean by hybrid systems? Why is this necessary?

A: Hybrid systems are systems that combine two or more different energy sources or technologies to generate electricity or meet other energy needs.

Hybrid systems are necessary because they can provide a more reliable and stable source of energy compared to systems that rely on a single energy source or technology.

There are several types of hybrid systems, including:

- Solar-wind hybrid systems.
- Solar-diesel hybrid systems.
- Wind-hydro hybrid systems.

Q: Briefly discuss the prospects of renewable energy sources in India. Discuss the obstacle to the implementation of renewable energy sources.

A: One of the main prospects of renewable energy sources in India is the availability of a large and diverse resource base. The country has abundant solar, wind, and hydro resources, and there is significant potential for the development of these resources. In addition, the government of India has implemented a number of policies and incentives to support the development and adoption of renewable energy technologies, including the National Solar Mission and the National Wind Energy Mission.

There are also several obstacles to the implementation of renewable energy sources in India. One of the main challenges is the high upfront cost of renewable energy technologies, which can make it difficult for individuals and businesses to adopt these technologies. In addition, the infrastructure and regulatory framework for renewable energy in India is still developing, which can create challenges for the development and deployment of renewable energy projects. Other challenges include a lack of public awareness and understanding of renewable energy technologies, as well as the availability of land and transmission infrastructure to support renewable energy projects.

Q: What is the principle of solar photovoltaic power generation? What are the main elements of a PV system?

A: The principle of solar photovoltaic (PV) power generation is based on the ability of certain materials, called semiconductors, to convert sunlight into electricity. PV cells, which are made of semiconductor materials such as silicon, are used to capture solar radiation and convert it into electrical energy.

The main elements of a PV system include:

- PV panels: PV panels are used to capture solar radiation and convert it into electrical energy.

- Inverter: The inverter is a device that converts the direct current (DC) electricity produced by the PV panels into alternating current (AC) electricity.

- Battery bank: A battery bank is a system of batteries that is used to store the excess electricity produced by the PV panels for use when the sun is not shining.

- Charge controller: It is used to prevent the battery bank from being overcharged or damaged.

- Mounting system: The mounting system is a structure that is used to support the PV panels and orient them towards the sun.

- Electrical wiring: Electrical wiring is used to connect the various components of the PV system, including the PV panels, the inverter, the battery bank, and the charge controller.

Q: What are the instruments used for measuring solar radiation and sunshine? Describe each with a sketch.

A: There are several instruments that are used for measuring solar radiation and sunshine, including:

- Pyranometer: A pyranometer is a device that is used to measure the intensity of global solar radiation. It consists of a sensor that is mounted on a flat surface and is sensitive to a wide range of wavelengths, including visible and ultraviolet light. The sensor is typically calibrated to measure the intensity of global solar radiation in units of watts per square meter (Wm^{-2}).

- Pyrheliometer: A pyrheliometer is a device that is used to measure the intensity of direct solar radiation. It consists of a sensor that is mounted on a flat surface and is sensitive to a narrow range of wavelengths, typically in the visible and near-infrared range. The sensor is typically calibrated to measure the intensity of direct solar radiation in units of watts per square meter (Wm^{-2}).

- Thermometer: A thermometer is a device that is used to measure the temperature of the air or other substances. It consists of a bulb that is filled with a liquid, such as mercury or alcohol, and is mounted on a scale. The temperature of the air or substance is determined by the expansion or contraction of the liquid in the bulb.

- Sunshine recorder: A sunshine recorder is a device that is used to measure the duration of sunshine at a particular location. It consists of a sensor, called a Campbell-Stokes recorder, which is mounted on a flat surface and is sensitive to a narrow range of wavelengths, typically in the visible and near-infrared range. The sensor is mounted on a circular scale, and as the sun's rays pass through the sensor, they leave a mark on the scale. The length of the mark is proportional to the duration of sunshine at the location.

Q: What are the main components of a flat plate solar collector? Explain the function of each with a sketch.

A: The main components of a flat plate solar collector include:

- Absorber: The absorber is the component of the solar collector that absorbs solar radiation and converts it into heat energy. It is typically made of a blackened metal, such as aluminum or copper, and is coated with a material that absorbs and retains heat.

- Cover: The cover is a transparent or translucent material that is placed over the absorber to allow solar radiation to pass through and be absorbed by the absorber. The cover is typically made of glass or plastic and is designed to be durable and weather-resistant.

- Insulation: The insulation is a material that is used to reduce the amount of heat that is lost from the solar collector. It is typically made of foam or fiberglass and is placed around the absorber to keep the heat inside the collector.

- Frame: The frame is the structural component of the solar collector that holds all the other components together. It is typically made of metal, such as aluminum or steel, and is designed to be durable and weather-resistant.

- Heat transfer fluid: The heat transfer fluid is a liquid or a gas that is used to transfer heat from the absorber to a storage tank or other heat exchanger. It is typically water or a mixture of water and antifreeze, and is circulated through the collector by a pump.

- Connecting tubes: The connecting tubes are used to connect the absorber to the storage tank or heat exchanger. They are typically made of metal, such as copper or aluminum, and are designed to be durable and weather-resistant.

Q: What is the overall heat loss coefficient? How is it related to heat loss in flat plate collectors?

A: The overall heat loss coefficient (U-value) is a measure of the heat loss from a flat plate solar collector. It is defined as the rate of heat loss per unit area of the collector, per degree temperature difference between the inside and outside of the collector. The U-value is typically expressed in watts per square meter per degree Celsius ($Wm^{-2}°C^{-1}$).

The U-value of a flat plate solar collector is related to the heat loss from the collector in the following ways:

- Insulation: The U-value is affected by the insulation used in the solar collector. The better the insulation, the lower the U-value, and the less heat that is lost from the collector.

- Cover: The U-value is affected by the cover used in the solar collector. The cover should have good solar radiation transmissivity and low thermal emissivity.

- Air tightness: The U-value is affected by the air tightness of the solar collector. If the collector is not airtight, heat can escape through gaps or leaks, which will increase the U-value.

- Ambient temperature: The U-value is affected by the ambient temperature outside the solar collector. The higher the ambient temperature, the higher the U-value, and the more heat that is lost from the collector.

Overall, the U-value of a flat plate solar collector is an important indicator of the efficiency of the collector. The lower the U-value, the less heat that is lost from the collector, and the more efficient the collector is.

Q: Explain briefly the construction and working of horizontal and vertical axis wind turbines with neat sketches.

A: A horizontal-axis wind turbine (HAWT) has a rotor shaft that is parallel to the ground, with blades that rotate around the shaft. The blades are typically attached to the rotor hub, which is connected to the main shaft. The main shaft is connected to a gearbox, which increases the rotation speed of the generator shaft connected, which converts the mechanical energy from the rotor into electrical energy. The generator is connected to a power inverter, which converts the direct current (DC) electricity generated by the generator into alternating current (AC) electricity that can be used in homes and businesses.

A vertical-axis wind turbine (VAWT) has a rotor shaft that is perpendicular to the ground, with blades that rotate around the shaft. The blades are typically attached to the rotor hub, which is connected to the main shaft. The main shaft is connected to a gearbox, which increases the rotation speed of the generator shaft connected, which converts the mechanical energy from the rotor into electrical energy. The generator is connected to a power inverter, which converts the direct current (DC) electricity generated by the generator into alternating current (AC) electricity that can be used in homes and businesses.

The main difference between HAWT and VAWT is the orientation of the rotor shaft. HAWT has a horizontal rotor shaft while VAWT has a vertical rotor shaft. VAWT is less common than HAWT. However, VAWT may have some advantages over HAWT, such as being less affected by wind direction, being more compact and easier to install and maintain, and being less visible. But also VAWT are less efficient than HAWT.

Q: Explain the terms:

1. Tethering control
2. Yaw control
3. Pitch control

A: The terms are explained as below:

- Tethering control: Tethering control refers to the ability of a wind turbine to adjust the length of the tether or cable that connects the turbine to the ground or a floating platform. By adjusting the length of the tether, the turbine can be positioned at different heights in the wind, allowing it to capture more energy from stronger winds at higher altitudes.

- Yaw control: Yaw control refers to the ability of a wind turbine to adjust the angle of the rotor blades in relation to the wind direction. By adjusting the yaw angle, the turbine can optimize its energy output by aligning the blades with the wind direction for maximum efficiency.

- Pitch control: Pitch control refers to the ability of a wind turbine to adjust the angle of the rotor blades in relation to the rotor shaft. By adjusting the pitch angle, the turbine can control the amount of torque or rotation of the blades, which can be used to regulate the turbine's energy output and protect the turbine from over-speeding or other damage.

Q: Explain the operation of a geothermal power plant.

A: A geothermal power plant is a facility that converts the heat energy from the Earth's interior into electricity. The basic principle of operation is to extract hot water and steam from deep within the Earth, and then use this thermal energy to drive a turbine that generates electricity.

Here's a general overview of the process:

1. Wells are drilled into geothermal reservoirs, which are typically located several kilometers below the Earth's surface. These wells are used to extract hot water and steam from the reservoir.

2. The hot water and steam are brought to the surface through the wells and directed to a heat exchanger. The heat exchanger is used to transfer the thermal energy from the hot water and steam to a fluid with a lower boiling point, such as water or a mixture of water and another substance.

3. The heated fluid is then used to drive a turbine, which generates electricity. The turbine is connected to a generator, which converts the mechanical energy from the turbine into electrical energy.

4. After passing through the turbine, the fluid is cooled and then returned to the geothermal reservoir through injection wells. This process is called the binary cycle.

5. The electricity generated is then sent to a transformer, which increases the voltage to a level that can be transmitted over long distances. It is then sent to the grid and distributed to consumers.

One important aspect to note is that while traditional power plants use fossil fuels to heat water to make steam which then drives turbines to generate electricity. In a geothermal power plant heat is already available from Earth's interior, no need for fossil fuels. This makes geothermal power a clean and renewable source of energy.

Q: Explain the construction and working principle of fuel cells with a neat sketch. What are the merits and demerits of this system?

A: A fuel cell is an electrochemical device that converts chemical energy from a fuel, such as hydrogen or natural gas, into electrical energy. The construction and working principle of a fuel cell are as follows:

- **Construction:** A fuel cell consists of an anode, a cathode, and an electrolyte. The anode and cathode are typically made of porous materials, and the electrolyte is a material that allows the movement of ions between the anode and cathode but does not allow the mixing of the two reactants. The anode is where the fuel is oxidized, and the cathode is where the oxidant is reduced. The fuel is typically hydrogen, which is supplied to the anode, and the oxidant is typically oxygen or air, which is supplied to the cathode.

- **Working principle:** When the fuel is supplied to the anode, it is oxidized, and the electrons are released. The electrolyte allows only the positively charged ions to pass through it and reach the cathode. The electrons released from the anode cannot pass through the electrolyte and must travel through an external circuit to the cathode, creating an electrical current. At the cathode, the oxidant reacts with the electrons and the positively charged ions from the anode to form water and release more energy.

Fuel cells have several advantages over other energy sources, including high efficiency, low emissions, quiet operation, and low maintenance requirements. They can operate continuously as long as the fuel and oxidant are supplied, making them ideal for stationary power generation applications. They also have the potential to be a zero-emission energy source if the fuel used is renewable, such as hydrogen produced from renewable energy sources.

But, the high cost of fuel cells is one of their major drawbacks. They also require a continuous supply of fuel and oxidant, which can be difficult to maintain, particularly in remote or off-grid locations. Another challenge is the lack of an established infrastructure for fuel cell technology, which limits their widespread adoption.

Q: Write a short note on bio-energy from agriculture waste.

A: Bioenergy from agricultural waste refers to the production of energy from organic matter that is produced in agricultural activities. This can include crop residues, animal manure, and other types of organic waste generated from farming operations.

The process of converting agricultural waste into bioenergy typically involves the use of anaerobic digestion or combustion technologies. In anaerobic digestion, microorganisms break down the organic matter in the waste in the absence of oxygen to produce biogas, which can be used to generate electricity or heat. In combustion, the waste is burned to produce steam, which can then be used to generate electricity or heat.

Q: Explain the equivalent circuit for solar PV panels.

A: The equivalent circuit for a solar PV panel is an electrical circuit that represents the electrical characteristics of the panel. The circuit consists of:

- A current source, which represents the solar panel's ability to generate current in response to incident solar radiation.
- A diode, which represents the voltage drop across the solar panel due to its inherent nonlinear behavior.
- A series resistance, which represents the resistance of the conducting wires and connectors that connect the solar panel to the load.
- A shunt resistance, which represents the leakage current that flows through the solar panel due to the inherent resistance of the material used in the panel.

All of the above components are connected in parallel.

Q: Explain the procedure for peltier cooling.

A: Peltier cooling is a type of solid-state cooling technology that utilizes the Peltier effect to create a temperature difference across a junction between two different types of materials.

The Peltier effect is a phenomenon where an electric current flowing through a junction of two different conductive materials can either absorb or release heat, depending on the direction of the current.